AUTOMATION AND MECHANIZATION OF PRODUCTION

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REGULATION OF THE EFFICIENCY OF SCREW FEEDERS FOR GLASS BATCH COMPONENTS

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Various designs of screw feeders for glass-batch components operating in the "precise" and "rough" proportioning modes are considered.

The efficiency of screw feeders operating in strain-gage proportioners for glass batch components depends on their design and on requirements imposed on the intensity and accuracy of proportioning materials. The intensity criterion

$$\varphi = \frac{Q_p}{Q_r},$$

which determines the optimum ratio between the efficiencies Q_p and Q_r in "precise" and "rough" proportioning [1], is of special significance in choosing the feeder design.

In the general case a simplified estimate of the screw feeder efficiency is performed according to the following formula [2]:

$$Q = 1.5\pi D^2 sk\gamma n,$$

where D is the outer diameter of the screw; s is the screw pitch; k is the screw feeder filling coefficient (0.25 – 0.40); γ is the bulk density of the material; n is the rotational speed of the screw.

Although this expression does not take into account the screw angle, the feeder shaft diameter, and some other parameters, it is evident that for a particular feeder design its efficiency depends on the rotational speed of the screw. Using a speed-adjustable drive, it is actually possible to attain a ten-fold ($\varphi = 0.1$) decrease in the feeder efficiency, which does not always ensure the minimal proportioning error expected for the prescribed efficiency. For instance, when the bulk density of the material or the screw feeder filling coefficient change, the material may be separated from the feeder even at a decreased proportioning rate. The proportioning error in this case depends on the screw diameter and pitch and on the physicochemical properties of material proportioned.

Therefore, to decrease the proportioning error, it is advisable to decrease the screw diameter and pitch, which, in turn, decreases the efficiency. To eliminate this contradiction, on should use double-screw feeders or feeders with variable diameter and pitch.

In a known technical solution [3] the discharge of material from the dosing unit (weighing based on discharge taking into account the residual container weight) is performed using a the screw feeder with a variable screw diameter, in which the small-diameter sector is located under the "precise" charging chamber and the larger-diameter sector is under the "rough" discharge chamber. These chambers are formed by a partition located in the conical part of the weighing hopper on the boundary between the sectors with the small and large screw diameters.

Initially, material is intensely discharged by both sectors of the screw feeder. Since the efficiency of the feeder is proportional to the pitch and the square of the screw diameter, the material from the "rough-discharge" chamber is unloaded 5 – 10 times faster After the discharge of the material from the rough-discharge chamber is completed, the feed of material continues from the precise-discharge chamber with a lower efficiency and a higher dosing accuracy (precise proportioning discharge mode).

The disadvantages of this feeder include the nonuniform discharge of materials from the dosing unit, the possibility of bridging, and spontaneous separation of material from the side of the "precise" chamber in precise proportioning.

In a similar technical solution of a feeder with a variable-diameter screw (RF patent No. 2008281) the absence of the partition creating the precise proportioning chamber decreases the probability of bridging of material in the conical

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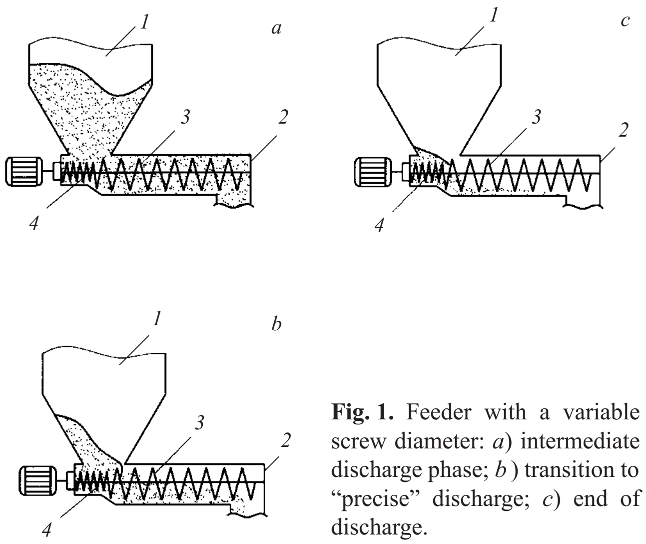

Fig. 1. Feeder with a variable screw diameter: *a*) intermediate discharge phase; *b*) transition to "precise" discharge; *c*) end of discharge.

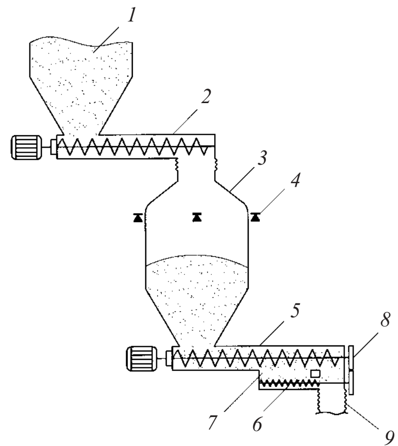

Fig. 2. Strain-gage proportioner with two-screw discharge feeder.

part of the weighing hopper. In this device (Fig. 1*a*) the material is initially discharged from the proportioner *1* by both sections of screw feeder *2*. Gradually a moment arises when, as a consequence of different output rates, the material above large-diameter screw *3* is completely unloaded, whereas a certain volume of material limited by the first sector of feeder *2* and the surface formed by the natural slope of the material discharged remains above small-diameter screw *4* (Fig. 1*b*). This residual volume is then unloaded only by feeder sector *4* with the small screw diameter. The proportioning process is completed after a prescribed weight is discharged from the weighing hopper (Fig. 1*c*).

Considering that the natural slope angle may vary due to fluctuations in the granulometric composition and moisture of material proportioned, the process of the transition to the "precise" weighing mode without an external controlling effect is as unstable, as this process in the presence of the partition.

All these drawbacks have been eliminated in a fundamentally novel design of the two-screw feeder for proportioning clotting glass-batch complements (RF patent No. 2117640, priority 13.09.96).

The weight proportioner with a two-screw discharge feeder (Fig. 2) consists of supply bunker *1*, loading screw feeder *2*, weighing hopper *3* with strain-gage weight-receiving device *4*, screw feeder *5* for "rough" discharge, screw feeder *6* with the small screw diameter, chamber of "precise" discharge *7*, gear transmission *8*, and discharge opening *9*.

The loading of the weighing hopper from the supply bunker is performed via screw feeder *2* and ends after the actual weight of material reaches the following value:

$$M_a = M_r + M_p;$$

where M_r and M_p are the residual and prescribed batch weights.

The introduction of setting M_r makes it possible to perform weighing with variable containers taking intro account accidental overweight and possible sticking of material to the weighing hopper walls. With this method it is possible to load the material only in the "rough" mode,.

The discharge of material from the proportioner starts after turning on the drive of screw feeder *5*, whose rotation is transmitted via the gear to screw feeder *6* with the small screw diameter. For the first 2 – 3 seconds the material is unloaded only from the "precise" discharge chamber, which contains the residual amount M_r from the preceding proportioning cycle. After the chamber is filled with material, the discharge from the proportioner is performed by both feeders in the "rough + precise" mode. The existence of rotating screw feeder 5 above the precise-discharge chamber and the movement of the material stabilize the process of filling the chamber and prevents bridging in it.

The "rough + precise" proportioning mode ends when there is no more material in the weighing hopper and in feeder *5*. After that the material is unloaded with a lower efficiency only from the precise-discharge chamber. The "precise" mode in this case is implemented without an additional controlling effect and without an additional drive. After the end of precise discharge some material is left in the precise chamber and its weight is taken into account in the next proportioning cycle.

By varying the ratio of diameters and the gear transmission coefficient, it is possible to attain the desired intensity criterion, whose optimum value is within the range of 0.04 – 0.10 depending on the properties of material proportioned.

A modification of this two-screw feeder allows for it application not only as an unloading feeder, but also as a loading two-velocity feeder (RF patent No. 2165901.).

In this feeder for clotting glass-batch components (Fig. 3) screw feeder *1* with a large screw diameter and screw feeder *2* with a small screw diameter located in "precise" discharge chamber *3* are connected with drive shaft *4* driven by reversible starter with *5* via two overrunning clutches *6*, *7* and gear transmission *8*. The gear transmission consists of

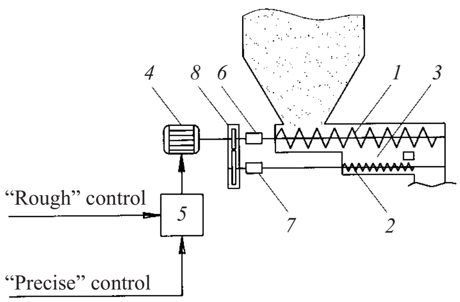

Fig. 3. Modified design of two-screw discharge feeder.

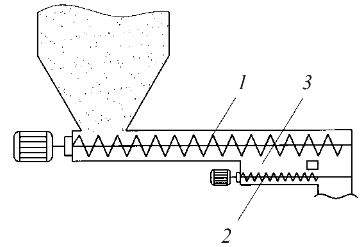

Fig. 4. Two-screw feeder with two independent drives: *1* and *2*) screw feeders of "rough" and "precise" material feed, respectively; *3*) chamber of precise feed of material.

the drive and driven gears rotating in opposite directions. The overrunning clutches depending on the rotation direction of the drive shaft transmit the rotation to one or the other screw feeder. This makes it possible to implement the transition from rough to precise feeding of material by simply reversing the supply voltage of the drive in the required proportioning stage.

The optimum design is a two-screw feeder with two independent electric drives (Fig. 4), which makes it possible to vary the feeder efficiency within a wide range and considerably simplifies its structure when the feeder length is over 1 m.

The Stromizmeritel' JSC has developed and is producing different sizes of two-screw feeders for clotting glass-batch components. Similar two-screw feeders with two electric drives are currently used in batch-preparation divisions of such world-known companies as Raute (Finland) and Zippe (Germany).

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